The Astronomy Village: Investigating the Universe

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1. Introduction

The Astronomy Village multimedia program is designed to emphasize the process of science as much as its content (Pompea and Blurton, 1995; Pompea, 1996). It was designed for 14 year-old students, but has been used at slightly younger age levels and for older students, including university students. The investigations are flexible enough to be used at this wide variety of levels.

In this CD-ROM-based multimedia program, student teams can pursue one of ten research investigations. In each investigation they are guided by a mentor, receive e-mail, hear a lecture in the Village auditorium, and make observations using ground or space-based telescopes in a virtual observatory. The students also process data using the *NIH Image* image processing program. They keep a detailed logbook of their research activities and can run simulations on stellar evolution as well as manipulate 3-D astronomy visualization tools. At the end, they present their research results to their classmates and answer questions about their results at a press conference. The Astronomy Village builds upon previous work in the use of image processing for education (Pompea, 1994a), teaching techniques in astronomy (Pompea, 1994b) current research in astronomy (Pompea, 1995), and developments in optics education (Pompea and Nofziger, 1995; Pompea and Stepp, 1995; Pompea, 1996).

2. The Astronomy Village Process Model

The process model for the Astronomy Village program is that students become members of one of ten potential research teams that are pursuing front-line observational astronomy research. In the Astronomy Village, the research process is broken down into five stages.

(1) In the "Background Research" phase, students read about their topic in the Library, listen to an introductory lecture in the Auditorium, are asked probing questions about the fundamental thinking behind the research, pursue hands-on experiments in the Hands-On Laboratory, and look at images in the Image Browser at the Observatory.

(2) In the next phase, "Data Collection", students plan an observation and do more thought and hands-on experiments related to their project.

(3) In the "Data Analysis" phase, students use an image processing program to extract more information from their data.

(4) In the "Data Interpretation" phase, students are looking critically at their data and draw broader results from it.

(5) In the "Presentation" phase of the research, the students consolidate their knowledge, critically examine their research and report on their observations and conclusions to other students. They also answer questions on their project at their press conference.

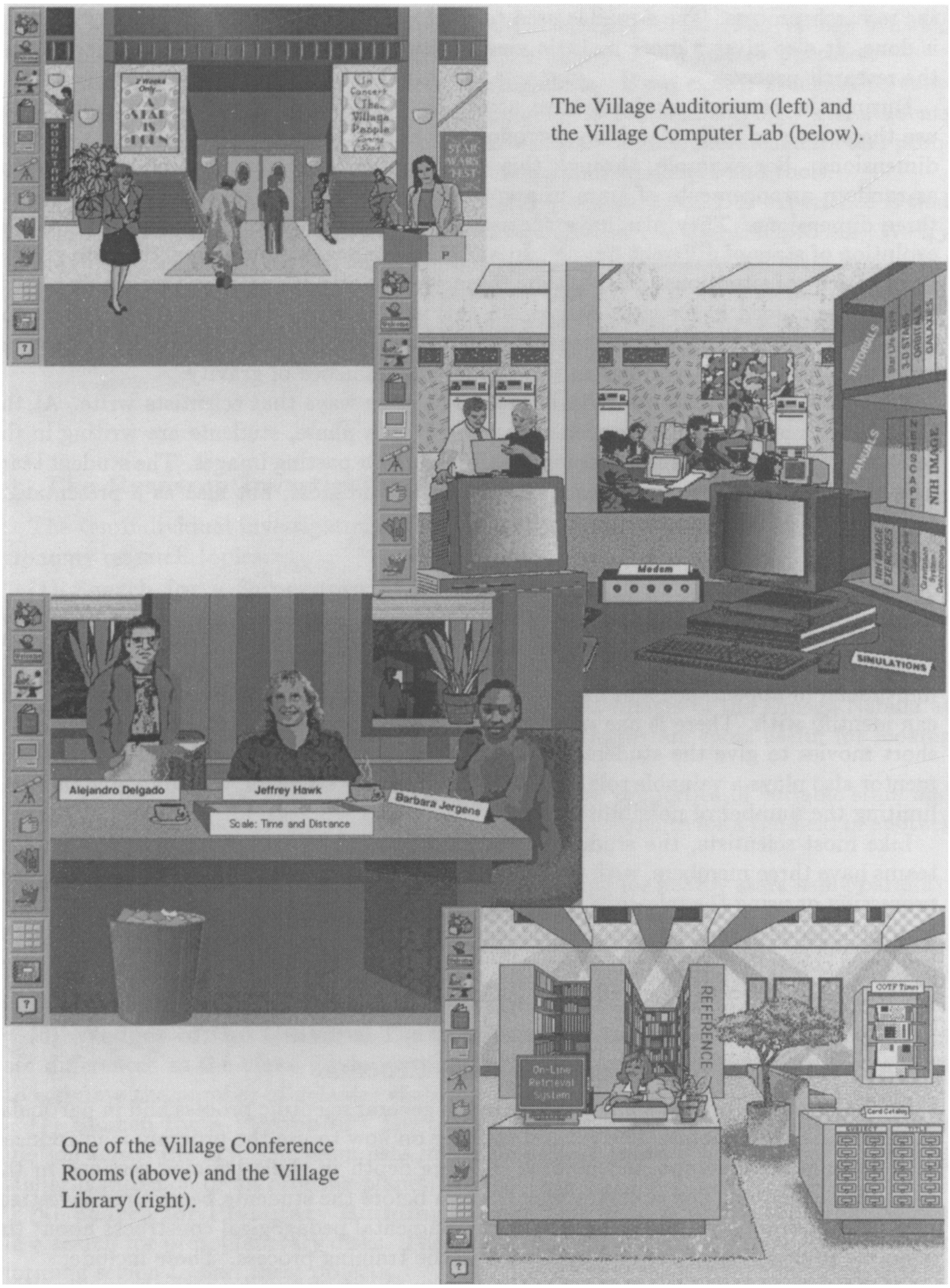

FIGURE 1.

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3. E-Mail and Visualization Tools

During these phases of the research process, the students receive electronic mail to welcome them to the research facility and as encouragement or guidance at key points in the research process. The e-mail is used to reinforce some key points about how research is done. It also gives a more realistic view of how new information can be injected into the research process.

During the research students have access to a variety of visualization tools. They use these tools to understand key astronomy concepts by manipulating objects in three dimensions. For example, through this manipulation they come to see constellations as random arrangements of stars in a spatial volume and the motion of these stars in three dimensions. They also have access to a stellar evolution simulator to follow the evolution of stars of different masses. In an orbital or gravity simulator, they are given a large variety of situations (solar system, binary encounter, asteroid swarm meets planet, etc.) programmed in for convenience. In this way students can better understand the dynamical evolution of a wide variety of planetary and stellar systems by letting the system go forward or backward in time under the influence of gravity.

We encourage students to write in much the same ways that scientists write. At the end of each research phase or even each activity in a phase, students are writing in the research notebooks, recording impressions, drawing, or pasting images. The student team uses their Log Books not only as a record of their progress, but also as a presentation tool when they have finished their research.

4. The Role of the Mentor and the Team

Mentors are an important part of the research process in the Astronomy Village. The mentor first introduces them to the investigation area. The mentors are muticultural and multiracial in appearance and name and provide a visual sign of diversity that students can identify with. There is one mentor for each investigation and this person appears in short movies to give the students guidance at each stage of the research process. The mentor also plays a valuable role, especially for younger students, in giving guidance and limiting the number of possibilities.

Like most scientists, the students work in cooperative research teams. The student teams have three members, with each student specializing in certain areas, such as image processing or using the telescope. The three roles are "observer", "researcher" and "data analyst". In each activity one student can take the lead. In this way the time on the keyboard controlling the computer can be shared by the students. The use of cooperative learning has proven to be an effective learning tool.

5. Assumptions About the Scientific Process

Students generally need some training in the general scientific process and in particular skills useful in astronomy. The general training on how to use the program is introduced in a 15 minute videotape and covered in more depth in skills training sessions in the Orientation Center. The skills training is given before the students begin their investigation. The Astronomy Village has certain fundamental pedagogical constructs about the scientific process which are also expressed in the training process. These include:

(a) Science is a contact sport. Students learn about science by actively constructing and discussing inferences, relations, comparisons, questions, and mental models. Knowledge is actively constructed by students, not passively received from the teacher or textbook.

(b) Science is a social activity. It is not an isolated activity, but occurs most often within groups and teams. The Village relies on a similar cooperative group process.

(c) Students should learn science the way that scientists do science. This is not to train them to become scientists, but to give them a more in-depth view of how science is done and the strengths and limitations of the scientific process. The Village five step model of the scientific process provides a sensible model of how science operates.

(d) Students need real-world problem solving skills. If we expect students to solve problems, they must be given practice and training in problem solving. The students working in the Astronomy Village are working with realistic astronomical data and problems and have access to a wide assortment of astronomical images and tools.

(e) Higher order thinking and creativity should be encouraged. Our experience is that few students at this age level have a solid understanding of the scientific process. We try to provide a sensible amount of structure but have tried to preserve the turns and twists inherent in the scientific process. We have done this by building in some blind alleys, some complexity, and some options and decisions for students. The realistic problems in the Village are designed to encourage higher order thinking skills.

6. The Research Investigations

The ten individual investigations in the Astronomy Village are related to current astronomy research topics:

(1) **Search for a Supernova** The supernova search team used data from neutrino detectors to locate a supernova. The team takes new images which are compared with archival images to find a supernova. If one is found, a light curve will be constructed to verify that it is a supernova and not another kind of variable star.

(2) **Looking at a Stellar Nursery** The team takes images of the Omega Nebula at several different wavelengths to identify which wavelengths are most useful for looking at different classes of young objects.

(3) **Variable Stars** This research team explores the properties of variable stars and uses Cepheid variables as "standard candles". The team searches for a Cepheid in another galaxy to in order to find the distance to that galaxy.

(4) **Search for Nearby Stars** This team is searching for nearby stars using parallax. Archival and current CCD images are used to identify several nearby stars.

(5) **Extragalactic Zoo** The research team explores different types of galaxies and clusters of galaxies to gain an understanding of galaxy environments and the scales of clusters of galaxies.

(6) **Wedges of the Universe** The team examines two sections or wedges of sky to see differences as the views go deeper and deeper into space. Students use these views to estimate the number of galaxies visible.

(7) **Search for a "Wobbler"** The team is looking for a star that is wobbling in its motion across the sky. The team uses image processing to see if a "wobbler" has a faint stellar companion or an orbiting planet.

(8) **Search for Planetary Building Blocks** This team examines the Orion Nebula in a search for protoplanetary disks. The teams constructs multicolor images of this star forming region to find these objects.

(9) **Search for Earth Crossing Objects** Will the Earth be hit by an earth-crossing asteroid? The team processes CCD data to find asteroids and try to determine if they will hit the Earth.

(10) **Observatory Site Selection** The team must make some decisions on site selection for a future observatory by evaluating five potential sites for light pollution, atmospheric stability, and accessibility.

The Astronomy Village can also be used as a database of astronomy articles and images. The Library has an on-line retrieval system that permits searching over 100 documents by author, subject, or title. The Observatory has over 300 images which can be searched by general topic. The teacher can also use the Astronomy Village as a presentation tool for an entire class or as a guide for student independent research projects.

7. Components of the Astronomy Village

The village metaphor is used to frame the research activities in each path. The interface allows students to interact with the program, navigate to different "facilities" within the village, and make use of various tools and resources. Here is a brief outline of the Astronomy Village components.

The Orientation Center The Orientation Center contains a Village tour that introduces the Village and its tools and resources to students. The tour is presented as a combination of computer graphics, audio, and video clips. The Orientation Center contains "skills building" activities that guide students through introductory activities to show them how to use the various facilities, tools, and resources within the Village.

The Conference Room The Conference Room contains the ten research questions from which teachers may assign projects or from which students may select projects.

The Observatory While in the Observatory, students are able to use a simulated telescope control panel to "capture" images of various objects at a variety of wavelengths. Both local observing and remote observing at a variety of sites are simulated. Students can also browse through an archive of over 300 images.

The Library The library contains an electronic catalog and search tools, the "COTF Times" newspaper (which contains articles illustrated with images), and a collection of NASA publications that focus on various aspects of astronomy (e.g. "Exploring the Universe with the Hubble Space Telescope"). There are over 150 articles in the Library.

The Computer Lab Within the Computer Lab students are able to access and use four tools: *NIH Image* (an image processing program), simulation programs, including a "Star Toolkit" which allows them to create stars of different masses and observe their life cycle, simulated e-mail, and a telecommunications program that allows them to connect to the NASA Classroom of the Future's server and to NASA SpaceLink.

The Hands-On Lab The Hands-On Labs contains directions for conducting experiments on and off the computer that teach, illustrate, or reinforce the astronomical concepts. Students will be able to print the directions to these experiments. There are over 25 Hands-On Labs.

The Auditorium The Auditorium provides students with twelve different 5-10 minute talks by astronomers related to the ten investigations. Each lecture is presented by means of audio recordings and illustrative computer graphics, video clips, and images.

The Cafeteria The Cafeteria is used by students to "overhear" astronomers informally talking about why they chose astronomy as a career, what being an astronomer is like, what it means to be engaged in scientific inquiry, and their specific research projects. There is also humor in the conversations, the menus, and the wall decorations.

The Press Conference At the end of each investigation, students get a chance to answer questions from the press. Sometimes the simplest questions are the hardest to answer!

Meta-tools There are four "meta-tools" students may access from any location within the Village. These include the Student Log Book, Calculator, Village Map, and Help. A fifth meta-tool is the "path" diagram, which outlines the types of activities possible when a more structured approach is desirable.

8. Running and Using the Software

The minimum system requirements are a Macintosh LC III running System 7 with 8 MB RAM, or a Power Macintosh with 16 MB of RAM; CD-ROM Drive; 20 MB on the hard drive; 13″ RGB color monitor (640 X 480 pixels, 256 colors); QuickTime™ 1.5; HyperCard™ 2.2 (not the HyperCard Player™). The Astronomy Software Village is available through NASA CORE and through NASA Teacher Resource Centers. The cost is nominal. For more information on obtaining the software, see the web pages on the Astronomy Village at the NASA Classroom of the Future: `http://www.cotf.edu`. Or, contact the Astronomy Village Project, NASA Classroom of the Future, Wheeling Jesuit University, Wheeling WV 26003. Phone (304) 243-2388; Fax (304) 243-2497.

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REFERENCES

POMPEA, S. M., 1994a, Image Processing Exercises for Astronomy, West Publishing.

POMPEA, S. M., ed. 1994b, Great Ideas for Teaching Astronomy, 2nd edition, West Publishing.

POMPEA, S. M., 1996, The Astronomy Village. In Astronomy Education: Current Developments, Future Coordination, ed. Percy, J.R. ASP Conference Series, vol. 89, pp. 259-261.

POMPEA. S. M. AND BLURTON, C., 1995, A Walk Through the Astronomy Village. Mercury, Jan–Feb.

POMPEA, S. M., ed., 1995, Current Perspectives in Physics and Astronomy, West Publishing.

POMPEA, S. M. AND NOFZIGER, M. J., 1995, Resources on optics in middle school education. In Proceedings SPIE: 1995 International Conference on Education in Optics ed. by Soileau, M.J., vol. 2525.

POMPEA, S. M. AND STEPP, L., 1995, Great Ideas for Teaching Optics. In Proceedings SPIE: 1995 International Conference on Education in Optics, ed. by Soileau, M.J., vol. 2525.

POMPEA, S. M., 1996, Arizona Optics Industry Association (AOIA) Focus Group Activities on Education. In Proceedings of the SPIE, Global Networking of Regional Optics Clusters, ed. by Breault, R.P., vol. 1550.